# Net-Centric Capability and Improved Battlefield Care

## Placing the Doctor in the Battlefield

Case Studies in Defense Transformation
Number 3

Stephen Prior and Susan Prior

Sponsored by the Office of the Deputy Assistant Secretary of Defense
Forces Transformation and Resources

Prepared by the Center for Technology and National Security Policy

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| | | |
|---|---|---|
| 1. REPORT DATE<br>**2007** | 2. REPORT TYPE | 3. DATES COVERED<br>**00-00-2007 to 00-00-2007** |

| | |
|---|---|
| 4. TITLE AND SUBTITLE<br>**Net-Centric Capability and Improved Battlefield Care. Placing the Doctor in the Battlefield** | 5a. CONTRACT NUMBER |
| | 5b. GRANT NUMBER |
| | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>**National Defense University,Center for Technology and National Security Policy,Fort Lesley J. McNair BG 20,Washington,DC,20319** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release; distribution unlimited**

13. SUPPLEMENTARY NOTES
**The original document contains color images.**

14. ABSTRACT

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT<br>**unclassified** | b. ABSTRACT<br>**unclassified** | c. THIS PAGE<br>**unclassified** | | **32** | |

**Standard Form 298 (Rev. 8-98)**
Prescribed by ANSI Std Z39-18

**Stephen Prior** is the President of Quantum Leap Health Sciences (Arlington, VA). He has over 20 years experience in biotechnology and has proven skills in the identification and appraisal of technology, project management and business development. He has held posts with both government and commercial organizations and has held academic posts with UK & U.S. agencies that are focused on biodefense. In the past several years he has been researching and publishing papers on the policy issues relating to technology, health and national security. He is a Distinguished Research Fellow at the National Defense University's Center for Technology and National Security Policy and the Executive Director of the National Center for Critical Incident Analysis.

**Susan Prior** is an independent consultant who has worked for over 20 years in the research and development of biological products and analysis of complex biological problems. She has worked with government agencies in both the United Kingdom and the United States as well as commercial organizations on both sides of the Atlantic. Her research experience includes an initial focus on molecular genetics and the development of pharmaceutical products. More recently she has used this experience to analyze and advise on policy issues relating to technology, health and national security.

## Introduction

Current priorities in combat casualty care for U.S. forces include treating casualties as far forward as possible and providing lifesaving interventions in an increasingly lethal battlespace with reduced infrastructure and logistics.[1] One of the key attributes of network-centric operation advanced by the Office of Force Transformation (OFT) is increased survivability for the force.[2] OFT also noted that past improvements in survivability have been garnered from “platform-centric” capabilities. With a new focus on network-centric capabilities it is appropriate to explore how this approach to operations and warfare may further benefit survivability in the battlespace.

It has been suggested that the survivability of our troops and mission success can be improved by expanding the flow of medical information on the battlefield and throughout the chain of command.[3] Currently available capabilities based on information technology (IT) can support this priority by developing solutions that will provide decision support tools for in-theater medical response. These technologies will provide capabilities for rapid location, diagnosis, and provisioning of effective trauma care to increase warfighter survival from battlefield injuries.

Advances in civilian emergency response have demonstrated the utility of some of the candidate IT-based technologies. At the present time, access to information including medical support is limited to vertical communication on the battlefield via the soldier with a radio. As more and more IT solutions are deployed in support of the troops, the level of information access and transmissibility will increase, offering new opportunities to enhance medical support. In a network-centric battlespace, many of these new IT-based capabilities could prove to be of great utility and ultimately may provide for even greater battlefield care for the troops and lower mortality rates during conflict.

The case study will outline some of the key civilian and military options for implementing IT-driven healthcare solutions. It also will identify issues that remain unresolved and some of the key hurdles for implementation into the network-centric battlespace.

## Background

In recent warfare, the great majority of combat mortalities occur before soldiers have had a chance to reach a Military Treatment Facility (MTF). The researchers at Dartmouth College, who are among the leading proponents of the use of medically oriented IT-

---

[1] Office of Naval Research, “Warfighter Performance Department, Code 34.” Available online at <http://www.onr.navy.mil/sci_tech/34/>.
[2] Office of Force Transformation, *The Implementation of Network-Centric Warfare* (Washington, DC: Department of Defense, January 2005). Available online at <http://www.oft.osd.mil/library/library_files/document_387_NCW_Book_LowRes.pdf>.
[3] Susan P. McGrath et al., “ARTEMIS: A Vision for Remote Triage and Emergency Management Information Integration,” November 30, 2003. Available online at <http://www.ists.dartmouth.edu/projects/frsensors/artemis/papers/ARTEMIS.pdf>.

capability for military use, have noted that their “primary target population is the 25 percent of soldiers killed in action who die between five minutes and six hours of injury.”[4] Their claim is that these soldiers live long enough to be rescued, but die quickly enough to be affected by the suboptimal nature of the current (medical) system. It is worth noting that of all the casualties that medics attempt to rescue, 25 percent are already dead before the medic arrives.[5]

It is apparent that tremendous strides have been made in the past 2 decades in the area of emergency medicine. This progress has, in effect, raised the stakes of battlefield medicine. This is especially true during the critical first 30 minutes after an injury, which accounts for 86 percent of combat deaths. This improvement means that survival from combat injuries has increased to 90 percent in the current conflict in Iraq and Afghanistan. This is 10 percent higher than Operation *Desert Storm* in the early 1990s and the highest for any conflict. There are several reasons for this improvement, including improved IT solutions that offer the possibility of even greater improvements if they can be effectively integrated and accommodated into an increasingly complex battlespace that is rapidly becoming restricted in terms of information flow because of limitations in communication bandwidth.

The civilian equivalents of battlefield medicine, emergency medical technicians (EMT), and ambulance care are also seeing a revolution in patient care from the insertion of IT solutions. Some of the successes offer lessons for battlefield medicine. Valuable lessons also can be learned about the obstacles to successful implementation, as well as what has proven less effective. Of course, road traffic accidents and disaster responses are not the battlefield, and care must be taken in making direct translations of how IT can contribute and what systems may be required for implementation. But, given the need to continue improving the medical care for our troops in the field, civilian medical IT innovations should be monitored and mined

One aspect of the modern battlefield that may provide a key component of an IT-based improvement, as well as an expansion of interconnectivity to facilitate some of the developing healthcare technologies, is the implementation of network-centric approaches to the battlespace. The network-centric approach and associated technologies enhances communications at all echelons within the force and across the battlespace. This study examines current civilian capabilities and considers how these may be effectively transitioned to the battlefield to further improve the survival rates for our forces.

## The Military Requirement

Clearly, battlefield medicine requires significant improvement to achieve reduced mortality and severity of casualties. However, with current treatment options being limited to: waiting for evacuation, providing intravenous fluids, applying field dressings, performing surgical control, implementing fracture stabilization, and administering

[4] Ibid.
[5] Ibid.

immediately available medications, the kinds of intervention and their success are much more limited than for comparable civilian settings. Conversely, with only limited options available to battlefield medics the impact of innovative technologies can be readily evaluated, assessed, and new methodologies or technologies developed.

**Medical**

It would be unreasonable to expect battlefield health providers trained to treat common illnesses and injuries to be able to provide the same level of knowledge and skill as experienced diagnostic specialists and emergency room surgeons. Worse yet, in some cases, the warfighter's buddy or the soldier himself may have to provide emergency care. Thus, there is a great need for an integrated, diagnostic, decision-support, and procedure-support system that can quickly:

- identify likely illnesses or injuries,
- offer information and assistance in resolving cases of inconclusive evidence, and
- provide detailed treatment instructions, consistent with the healthcare provider's level of expertise.

Moreover, the provision of the IT system outlined above needs to be accomplished by troops with training that ranges from combat lifesaver training, through medics, to highly trained medical specialists.

**Information Technology**

The Department of Defense (DOD) is investing significantly in information systems to support network-centric military capabilities and joint operations. The integration of health and combat care requirements into this expanded IT-based capability is an important component, but as a requirement it will have to compete with a wide spectrum of other IT-rich capabilities (most of which are not related to medical concerns), all seeking to use a military IT backbone with limited bandwidth.[6]

In contrast, the civilian sector faces much less of a problem, especially in urban areas where wireless connectivity, broadband access, and other IT support frameworks are becoming ever more abundant. In fact, one of the major reasons why the civilian systems discussed in this paper have developed so rapidly over the past decade is the ease of access to this backbone and the abundant bandwidth for transmission of relevant information. The civilian developers of IT-based healthcare capability have not yet had to face many limitations, although experiences in rural areas suggest that the situation in less IT-rich environments may require some of the innovations that the military research teams are developing.

---

[6] For a review of issues surrounding IT implementation in DOD, see Joseph Mait, editor, *Making IT Happen: Transforming Military Information Technology,* Defense & Technology Paper 20 (Washington, DC: Center For Technology and National Security Policy, September 2005).

Where bandwidth is limited, solutions, such as the development of multiple, redundant routing for data and methods for queuing data packages, are being explored. Each of these potential solutions could be assessed for utilization on the battlefield but, given the life and death nature of the medical requirement, resolution of the bandwidth issues, and prioritization versus other users, are important issues for effective troop deployment. In this context, it is important to note that combat injuries are by their very nature episodic and thus do not require constant use of limited bandwidth. Nonetheless, when injuries occur, they impact not only levels of morbidity and mortality but also morale. Few things impact morale more positively than a service life saved; few things impact troops as negatively as a life lost because of an ineffective or inefficient response.

**Military Requirements**

A future system should be capable of: extracting information from the soldier, analyzing it to transform raw data into clinically useful information, and distributing this information across a network in an efficient and expeditious manner.

**Civilian Requirements**

The requirement in the civilian sector begins with the same goal of saving lives through effective medical intervention. Several other requirements are common to both environments:

- improving medic efficacy,
- establishing baseline metrics for EMS via in-depth reporting and analysis of operational data,
- ensuring complete patient care reports, and
- using integrated field data for syndromic surveillance[7] and other linked capabilities.

Moreover, the civilian requirement can be readily categorized into two areas: emergency response to single or multiple trauma events and disaster response. These definitions become blurred when the trauma event exceeds 10 or so patients, but in general this separation helps to define the two areas of concern for developing a robust civilian capability. It also helps to separate two different IT requirements: the detailed patient-by-patient information on which to make clinical decisions prior to a patient’s entering the treatment facility and the population-focused disaster response, which demands decisions about triage, prioritization, and facility use, among other things. In a later section the progress towards these two goals is described but in both cases the available IT backbone and medical resources in the civilian sector outweigh the likely military capacity.

[7] The term “syndromic surveillance” applies to surveillance using health-related data that precede diagnosis and signal a sufficient probability of a case or an outbreak to warrant further public health response. Though historically syndromic surveillance has been utilized to target investigation of potential cases, its utility for detecting outbreaks associated with bioterrorism is increasingly being explored by public health officials. http://www.cdc.gov/EPO/dphsi/syndromic.htm.

Additional burdens in the civilian sector are imposed by concerns with liability, privacy, and confidentiality. These either do not apply or represent issues of only limited concern in the military battlespace. However, higher echelons of military care do attempt to:

- reduce risk in the event of litigation or audits,
- eliminate inefficient paper processes,
- ensure protocol is followed consistently on each call,
- establish baseline metrics for emergency medical services (EMS) via in-depth reporting and analysis of operational data.

To limit the inclusion of data that has only limited value in comparing the military and civilian sectors, these considerations are not addressed in this paper.

**Case Study Elements**

- Emergency (Trauma) Care
  - Civilian Capabilities
  - Military Care Echelons and Combat Care
  - Military Capabilities and Restrictions
- Network-centric Operations: Improving IT and Medical Capability in the Battlespace

## Emergency (Trauma) Care Civilian Capabilities

Improving patient survivability by moving information and resources closer to casualties in the field is a major objective of casualty/trauma care research. It has been estimated that, of 150,000 trauma deaths occurring each year in the United States, some 25,000 could be prevented by improving immediate trauma care, and that an orchestrated trauma system could reduce preventable deaths by as much as 80 percent.[8]

The origin of the modern civilian trauma system can be traced back to the American College of Surgeons (founded in 1922), which established a number of committees aimed at improving medical care. From an initial interest in fractures and hospital standardization, the college went on to form the Board of Industrial Medicine and Traumatic Injury in 1926. From these beginnings, great strides in hospital-based emergency care were largely a result of improvements in medical practices stemming from the U.S. military's wartime experiences.[9] The concept of the civilian paramedic was introduced following the Vietnam War, when there had been a need to train non-medical personnel to assist with the injured prior to transportation to a medical facility. The first attempt at providing a coordinated, systematic approach to civilian emergency care was introduced in1966 in Cook County, CA, when the first civilian trauma unit was opened at

[8] Branas et al., "A Case Series Analysis of Mass Casualty Incidents," *Prehosp Emerg Care* 2000, Vol. 4;299-304.
[9] D.R. Boyd, "The History of Emergency Medical Services (EMS) Systems in the United States of America," in: *Systems Approach to Emergency Medical Care*, D.R. Boyd, R.F. Edlich, and S.H. Micik, eds. (Norwalk, CN: Appleton-Century-Crofts, 1983.)

the San Francisco General Hospital. This was shortly followed by the first statewide system, which was implemented in Maryland.[10]

Before enactment of the Trauma Care Systems Planning and Development Act (PL 101-590) in 1990, only a few states had trauma systems. An inventory of trauma centers published in 2003 indicated that 50 states had 1,154 centers in operation. The trauma centers are categorized as levels I through V according to the level of care that can be provided, which is an important part of the determination of where a patient should be sent. [11] Since the inception of trauma/emergency systems, numerous studies cited in medical literature have indicated that when they are in operation, the likelihood of a beneficial outcome increases.[12]

Concomitant with the development of trauma systems was the development of instrumentation and practices to support medical care. Within the field of cardiology it was recognized in the 1960s that a capability to provide mobile coronary care had the potential to significantly reduce mortality in heart attack (HA) cases.[13] In the United States, initial attempts at providing mobile coronary care were introduced in 1968 by New York City's St. Vincent's Hospital, which transported physicians to suspected HA patients.

While this early concept of mobile care was undoubtedly beneficial, it made inefficient use of physician time. A capability was needed to relay information about a patient to the most relevant physician in a particular hospital. One of the first attempts at combining mobile data output capabilities with medical support was Medtronic's LIFEPAK® 2 defibrillator/monitor, which was introduced in 1972. This was the first portable defibrillator to allow transmission of the patient's electrocardiograph (ECG) signal from an emergency vehicle to physicians waiting at the hospital. In the decades since, improvements to the flow of information related to emergency response systems have been hampered by technological constraints on communication and instrumentation. For years the systems in operation forced emergency medical response communities to rely upon paper triage tags, clipboards of notes, and verbal communications using telephones and handheld radios for sharing information during a medical emergency. Such an approach was judged to be labor intensive, time consuming, and of most concern, prone to human error. Furthermore, under certain circumstances of trauma, it is not always possible to transport a patient immediately. In these situations, secondary injuries, such as

---

[10] D.D. Trunkery, "History and development of trauma care in the United States," *Clinical Orthopaedics and Related Research*, 2000, Vol. 374; 36-46.

[11] Committee on the Future of Emergency Care in the United States Health System, *Hospital-Based Emergency Care* (Washington, DC: National Academy Press, 2006).

[12] S.R. Shackford, R.C. Mackersie, and D.B. Hoyt , "Impact of a trauma system on outcome of severely injured patients," *Archives of Surgery*, 1987; 122: 523–527; D.A. Guss et al, "The impact of a regionalized trauma system on trauma care in San Diego County," *Annals of Emergency Medicine*, 1989, vol. 18; 1141-1145; G. Kane et al, "Impact of the Los Angeles County trauma system on the survival of seriously injured patients," *Journal of Trauma*, 1992, Vol. 32;576-583; R.J. Mullins et al, "Outcome of hospitalized injured patients after institution of a trauma system in an urban area," *JAMA*, 1994, vol. 271;1919-1924.

[13] J.F. Pantridge and J.S. Geddes, "A mobile intensive-care unit in the management of myocardial infarction," *Lancet*, 1967, vol. 2;271-273.

hypoxemia, hypotension, and cardiac tamponade[14], can become life-threatening and require urgent, pre-hospital interventions.[15]

An initial solution to these drawbacks became possible with the advent of technology that allowed patient information to be captured electronically at the scene of an emergency and wirelessly transferred to clinical and operational staff. Using powerful, mobile, data collection software and ruggedized, touch-screen tablet personal computers, emergency paramedics are now able to document such patient information as event location/time, patient status, and initial treatment. Transmission of this type of data alerts hospitals and allows them to prepare for the patient. Additionally, by simply hooking the Tablet to a printer, paramedics can generate a complete and legible patient record on arrival at the hospital.

A number of companies have now fielded electronic patient care reporting systems for use by emergency medical services. Zoll Data Systems based in Broomfield, CO,[16] claims that its RescueNet™ TabletPCR combines proven technology with the most advanced user interface available. [17] Other tablet personal computer (PC) systems include Medtronic's LIFENET® EMS[18] and MobiMed, which is produced in Europe by MEDOS AG.[19] The concept has been further advanced by the availability of affordable "pocket" PC 2002 compatible personal digital assistants (PDA) devices capable of being used by emergency responders, such as RescueNet™ PocketPCR.[20]

In addition to capturing initial data keyed in by an emergency responder, systems such as RescueNet™ TabletPCR can automatically import data from medical sensors such as cardiac monitors. Previously, an emergency crew would have to write down or key in vital signs and events collected by a monitor.

The systems described above have led to significant advances in emergency care, enabling field data collection to become more standardized, less error-prone, and more efficient. The integration of medical monitors and the automatic capture of vital pre-hospital data further improve decision support to emergency medics. However, these systems are only suited to tracking data and vital signs of individual patients. To date there are no fully validated/fielded systems capable of automated monitoring and tracking of mass casualties. Existing systems are confined to the bedside and require mainframe computing systems that are not consistent with "in field" usage.

[14] Cardiac tamponade is the compression of the heart caused by blood or fluid accumulation in the space between the myocardium (the muscle of the heart) and the pericardium (the outer covering sac of the heart). http://www.nlm.nih.gov/medlineplus/ency/article/000194.htm.

[15] Tia Gao and David White, "A next generation electronic triage to aid mass casualty emergency medical response," June 10, 2006. Available online at <http://www.aid-n.org/about/Pub/EMBS_2006_Triage.pdf>.

[16] <http://www.zolldata.com/csite/ProductsRNet.asp>.

[17] <http://www.zolldata.com/csite/ProductsFDataPC.asp>.

[18] <http://www.medtronic-ers.com/>.

[19] <http://www.medos.de/en/Produkte/MobiMed/MobiMed.php?navid=37>.

[20] <http://www.zolldata.com/csite/ProductsFDataPPC.asp>.

As recently as 2003, most automated medical monitors/sensors relied upon hard-wired capability to connect the sensors on the body to the measurement equipment. With the advent of Bluetooth wireless technology, suppliers of medical monitoring equipment are increasingly exploiting the wireless concept to improve upon their own technology. One of the first of these new systems licensed for use by the Food and Drug Administration (FDA), was the Lifesync[R] wireless ECG produced by GMP Wireless Medicine, Inc.,[21] which was first adopted by the Mercy Hospital, FL, in 2004. An overview of the application of wireless technology to the medical field has been published online by Washington University in St. Louis.[22]

Wireless monitoring equipment may solve the recognized need to be able to transition the status tracking of multiple patients from a bedside capability to an "in field" capability. This capability could dramatically improve management of disasters that cause mass casualties. If emergency field personnel and hospital staff are to be able to provide effective trauma care without being overwhelmed, first responders need to be able to rapidly triage the injured and severely injured in a coordinated manner. Traditionally, the triage process has occurred at the hospital gate—most often at the entrance to the emergency department. The earlier a decision can be made regarding a patients needs, the better the quality of care and the more efficient the use of resources. The lack of coordination associated with directing a patient to the most appropriate setting was cited as a critical issue impacting the delivery of emergency care in a recent publication by the Committee on the Future of Emergency Care in the United States Health System.[23]

An emergent class of devices known as Sensor Networks are claimed to have the potential to revolutionize the capability of first responders to capture, process, and communicate critical data.[24] The networks are said to represent the next step in wireless communication miniaturization. They consist of small, low-power/low-cost devices with limited computational and wireless communications capabilities. Due to the low power requirements and small size of the devices, it is thought possible that they could be embedded into wearable vital signs monitors and location-tracking devices for both patients and first responders. As components of a disaster management solution, sensor network experts believe that they could be utilized for:

- in-field patient triage and tracking,
- temporary storage of individual patient information, including on-scene physical exam findings, treatment types, and treatment response,
- simultaneous physical environmental monitoring, and
- tracking location and status of first responders and patients.

[21] <http://www.wirelessecg.com/>.
[22] Ibrahim Noorzaie, "Survey Paper: Medical Applications of Wireless Networks," April 24, 2006. Available online at <http://www.cs.wustl.edu/~jain/cse574-06/ftp/medical_wireless/index.html>.
[23] Committee on the Future of Emergency Care in the United States Health System, *Hospital-Based Emergency Care* (Washington, DC: National Academy Press, 2006).
[24] Konrad Lorincz et al, "Sensor Networks for Emergency Response: Challenges and Opportunities," *IEEE Pervasive Computing*, Special Issue on Pervasive Computing for First Response, Oct-Dec 2004. Available online at <http://www.eecs.harvard.edu/~mdw/papers/codeblue-ieeepvc04.pdf>.

However, compared to traditional sensor networks, those devised for suitable applications of medical monitoring need to be able to provide high rates of data transmission and reliable communications to multiple receivers, such as medics' PDAs. Moreover, systems designed for medical use could not use traditional in-network aggregation, because it would be inappropriate to combine data from more than one individual.[25]

A wireless sensor network at the forefront of medical care research is the CodeBlue system, which is being developed by the Division of Engineering and Applied Sciences, Harvard University.[26] CodeBlue software is designed to provide routing, naming, discovery, and security for wireless medical sensors, PDAs, PCs, and other devices that may be used to monitor and treat patients in a range of medical settings. CodeBlue is also designed to scale across a wide range of network densities, ranging from sparse clinic and hospital deployments to very dense, ad hoc deployments at a mass casualty site.[27]

The CodeBlue platform (with a modified MOTE™ system)[28] has been incorporated into a next generation electronic triage system—the Advanced Health and disaster Aid Network (AID-N), which is being developed by the Johns Hopkins University Applied Physics laboratory.[29] A prototype system has been developed in collaboration with three EMS groups in the Washington, DC, Metropolitan area; the CodeBlue sensor network has been integrated with the MICHAELS (OPTIMUS Corporation) pre-hospital, patient care software. The standard MICHAELS system has been modified so that it can automatically record and analyze a patient's vital signs on a PDA device and inform a responder of abnormal changes in status. Additional information, including patient ID, triage details, treatments, photographs, and location, is immediately transmitted to a remote server for further dissemination. Information can be viewed from the server by Emergency Department personnel, incident commanders, and remote medical specialists to enable a coordinated and effective response.

In addition to AID-N, the Code Blue Platform is also being incorporated into the iRevive Airmedical Patient Care System, which is being developed by 10Blade in conjunction with Boston Medflight.[30] A unique feature of this system is said to be its use of knowledge-based rules to compile accurate data, including streaming vital signs data, procedural information, and response to treatment "real-time" into a patient's record.

---

[25] Victor Shnayder et al, "Sensor Networks for Medical Care," Harvard University Technical Report TR-08-05, 2005. Available online at <http://www.eecs.harvard.edu/~mdw/papers/codeblue-techrept05.pdf>.
[26] <http://www.eecs.harvard.edu/~mdw/proj/codeblue/>.
[27] David Malan et al, "CodeBlue: An Ad Hoc Sensor Network Infrastructure for Emergency Medical Care," 2004. Available online at <http://www.eecs.harvard.edu/~mdw/papers/codeblue-bsn04.pdf>.
[28] Tia Gao et al, "Vital signs monitoring and patient tracking over a wireless network." Proceedings 27th IEEE EMBS Annual International Conference, September 2005. Available online at <http://www.eecs.harvard.edu/~mdw/papers/monitoring-embs05.pdf>.
[29] Tia Gao et al, "Improving Patient Monitoring and Tracking in Emergency Response," Proceedings of International Conference on Information Communication Technologies in Health, July 2005. Available online at <http://www.eecs.harvard.edu/~mdw/papers/monitoring-icicth05.pdf>.
[30] <www.10blade.com>

While the above noted research has tremendous implications for the improvement of civilian medical emergency care, the development of the prototype systems is already beginning to highlight issues that may impact their progress. Notwithstanding difficulties associated with implementing novel technologies, of concern when responding to civilian needs, would be the lack of a centralized patient database. To facilitate an optimal response, physicians must have access to as complete a patient record as possible so that they can take into account previous medical conditions and therapies when making lifesaving decisions. Also of importance is the requirement to maintain patient confidentiality. This will be of utmost importance when multiple responders may be involved in the "handover" of a patient and that person's data, were it to be accessible from a centralized patient database.

## Military Care Echelons and Combat Care

The requirements for U.S. military combat care have been established over the 230–year history of army medicine. Each of the services has a slightly different basis for addressing the requirements; clearly the types of injury and capabilities in the U.S. Navy or U.S. Air Force are different from those of the Army and Marine Corps, but the principles remain constant. This paper will focus on land forces and will identify opportunities, challenges, and network-centric requirements based on an Army approach to casualty care.

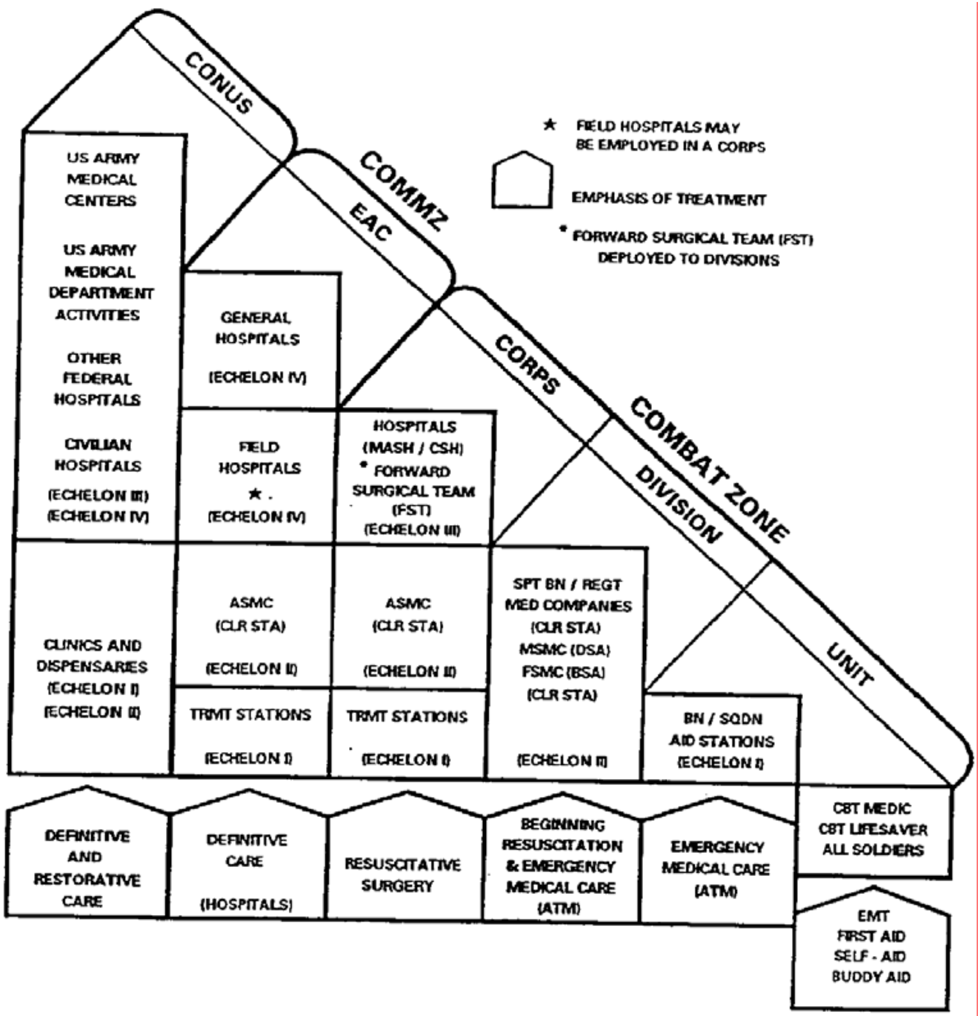
**The Combat Health Support System (CHS)**
The mission of CHS, to "conserve the fighting strength," is accomplished by prevention, treatment, and evacuation. The CHS system provides medical care as far forward on the battlefield as the tactical situation will permit, allowing the maximum number of combat soldiers to return to duty (RTD) as early as possible.[31]

**Echelons of Combat Health Support**
Combat health support is arranged in echelons (levels) of care. Each echelon of care reflects an increase in CHS capabilities while retaining capabilities found in preceding levels of care.

---

[31] U.S. Army, *Publication SH* WVBN003B. Available online at <http://ncoa.amedd.army.mil/PrintDocs/03_SH_CHS%20Sys.doc>.

**Figure 1. Echelons of Combat Health Support**




ASMC – area support medical company
ATM – advanced trauma management
BN – battalion
BSA – brigade support area
CB – combat
CLR STA – clearing station
COMMZ – communications zone
CSH – combat support hospital
DS – division support area
EAC– echelons above corps
EMT – emergency medical treatment
FSMC – FORWARD support medical company
FST – FORWARD surgical team
MASH – mobile army surgical hospital
MED – medical
MSMC– main support medical company
REGT – regiment.
SPT BN – support battalion
SQDN – squadron
TRMT – treatment

## Traditional Army Medical Wartime Structure[32]

The Army's health service support system is designed to be a single, integrated system that reaches from the combat zone in the theater to the continental United States (CONUS). The underlying idea is that the system is a continuum of care in which a soldier injured on the battlefield will be provided a full range of services, from simple first aid in the theater to more definitive care at a fixed facility within CONUS or Europe. To meet these wartime needs, health service support in the theater of operations is organized into echelons of care. These echelons extend rearward throughout the theater and depend on a reliable evacuation system.

**Echelon I.** Echelon I, the first medical care a soldier receives, is unit-level health care, which includes treatment and evacuation from the point of injury or illness to the unit's aid station. This echelon includes immediate, lifesaving measures, disease and non-battle injuries (DNBI) prevention, combat stress support, casualty collection, and evacuation to a supporting medical treatment facility. At this echelon, medical care encompasses self-aid, buddy aid, combat lifesaver, combat medics, and a treatment squad (battalion aid station).

**Echelon II.** Echelon II is division-level health service support, which includes evacuating patients from the unit-level aid stations and providing initial resuscitative treatment in division-level medical facilities. This echelon includes medical companies, support battalions, medical battalions, and forward surgical teams, as well as intra-theater patient evacuation assets. At Echelon II, emergency care, including beginning resuscitation procedures, is continued. Soldiers who can be returned to duty within 24–72 hours are held at this echelon for treatment.

**Echelon III.** Echelon III is corps-level health service support, which includes evacuating patients from supported divisional and non-divisional units and providing resuscitative and hospital care. In addition, Echelon III includes providing area health service support within the corps' area to units without organic medical units. Echelon III care is provided by such units as mobile army surgical hospitals (MASH), combat support hospitals (CSH), evacuation hospitals (EVAC), and field hospitals (FH). Patients unable to survive movement over long distances receive surgical care in an Echelon III hospital. In these theater hospitals, patients receive care that will either allow them to be returned to duty or stabilized for evacuation out of the corps or out of the theater altogether.

**Echelon IV**. Echelon IV is a communications zone (COMMZ)-level health service support, which receives patients evacuated from the corps. This echelon involves treating the casualty in a general hospital and other COMMZ-level facilities. Here, patients receive further treatment to stabilize them for their evacuation to CONUS.

---

[32] Lois M. Davis, et al, “Army Medical Support for Peace Operations and Humanitarian Assistance.” Available online at <http://www.rand.org/pubs/monograph_reports/MR773/index.html>.

**Echelon V**. Echelon V is the most definitive care provided to all categories of patients in CONUS and out of CONUS Army hospitals. Echelon V is the CONUS-sustaining base and is where the ultimate treatment capability for patients from the theater resides, including full rehabilitative care and tertiary-level care.

The echelons and types of care are summarized in table 1.

**Table 1. Echelons and Types of Care Provided**

| **Echelon** | **Facility** | **Type of Care** |
|---|---|---|
| **I** | Battalion Aid Station | Tactical Combat Casualty Care |
| **II** | Medical Company | Field Troop Medical Clinic |
| **III** | Combat Support Hospital | Specialty-based "hospital" care |
| **IV** | Theater Hospital | Rehabilitate and return to duty |
| **V** | Home Station Hospital | Long-term recovery |

### Assumptions about the Medical Structure

- Health service support will be a single, integrated system that reaches from the forward area of a combat zone as far rearward as the patient's condition requires, including to CONUS.[33]
- The different echelons of care will be connected, allowing for the uninterrupted care and treatment of the wounded, injured, or sick.[34]
- Fixed facilities will exist at Echelons IV and V to which patients can be evacuated from the theater.
- The system is geared toward stabilizing and evacuating patients from the theater to a more definitive level of care, when necessary.
- A viable and timely evacuation system exists, with dedicated MEDEVAC aircraft and personnel assigned to the mission.
- A viable medical logistics supply system exists that is based on FDA standards.
- U.S. military standards of quality of medical care and equipment, units, personnel, and training will be adhered to.

### Assumptions about the Nature of the Patient Population

- Troops will represent a healthy, young adult population (predominantly male).
- Troops will have a high level of medical and dental readiness, minimizing the number of chronic and acute medical conditions that may require treatment in the theater of operations.
- Troops will have good preventive medicine support throughout the course of deployment and during the predeployment phases.

---

[33] Doctrine for Health Service Support in Joint Operations, Joint Pub 4-02, April 16, 1995, 1-6.
[34] Ibid.

### Assumptions about the Demand for Services

- The demand for medical services will tend to be primarily for trauma and surgical care, since good preventive medicine support and a high level of physical readiness of troops will serve to minimize DNBIs requiring treatment in the theater itself.
- The range of diseases expected to require treatment in the theater will be limited to naturally occurring and common infectious diseases, such as upper respiratory infections, and to diseases endemic to a particular region.

In addition to the formal echelons of care outlined above, it is important to note that over the last 15 years, since before the Operation *Desert Storm*, a new concept in war surgery has emerged called the *forward surgical team*.[35] Taking lessons learned from civilian trauma centers, the methods of damage control were applied to war surgery. Damage control techniques involve using multiple short surgeries instead of one long surgery to care for severe trauma. This practice allows more time for the body to catch up with blood loss and infection, and has proven a very important to the increased survival of severely injured patients on the civilian side. The military version is small, highly mobile surgery units that can move with combat units and provide front line surgical care. In keeping with the damage control concept, the surgery done at these facilities is short, limited, and not complex. Essentially, bleeding and ongoing contamination from leaking bowels are controlled, and the patient is quickly transferred to a higher level of care. Because of the dichotomy of providing highly specialized care in a very forward position, it falls outside the usual echelon classification system.

### Tactical Combat Casualty Care and Environments of Care

Tactical Combat Casualty Care (TCCC or TC3) is integral to the U.S. Army training doctrine for medics.[36] It incorporates principles for provision of immediate evaluation and management in combat environments. The combat environment is the element that determines how TC3 differs from standardized evaluation and management strategies in non-combat (e.g. civilian and non-combat military) environments.

Military Occupational Specialty (MOS) training for the U.S. Army Combat Medic is currently based on the principals of a Department of Transportation (DOT) EMT Basic course, and Basic and Advanced Trauma Life Support (ATLS). While these guidelines provide a standardized, systematic approach to the management of the civilian trauma patient, some of these principles may not apply to the combat setting. Importantly, the pre-hospital phase of caring for combat casualties continues to be critical, since up to 90 percent of combat deaths occur on the battlefield before a casualty reaches a MTF. Such

---

[35] ABC News, “Military Surgeons-Echelons of Care,” March 15, 2006. Available online at <http://abclocal.go.com/wpvi/story?section=nation_world&id=4110147>.

[36] Fleming-Michael, K. “Medic's Powerful Tool Tracks Care,” *Hot News*, 18th Medical Command InterNet, 2003. Available online at <http://www.seoul.amedd.army.mil/sub/highlight/n_view.asp?num=3>. See also <http://www.tatrc.org/website_bmist/index.html and https://www.mc4.army.mil/BMIST-J.asp>.

factors as enemy fire, medical equipment limitations, a widely variable evacuation time, tactical considerations, and the unique problems entailed in transporting casualties must all be addressed. The three goals of TC3 are: treat the casualty, prevent additional casualties, and complete the mission.

### Stages of Care

In making the transition from the standards of civilian emergency care to the tactical setting, it is useful to consider the management of casualties that occur during combat missions as being divided into three distinct phases: care under fire, tactical field care, and combat casualty evacuation care (CASEVAC).[37] This approach recognizes a particularly important principle—performing the correct intervention at the correct time in the continuum of field care. A medically correct intervention at the wrong time in combat may lead to further casualties.

*Care under fire* is the care rendered by the medic at the scene of the injury, while he and the casualty are still under effective hostile fire. Available medical equipment is limited to that carried by the individual soldier or the medic in his aid bag.

*Tactical field care* is the care rendered by the medic once he and the casualty are no longer under effective hostile fire. It also applies to situations in which an injury has occurred on a mission, but there has been no hostile fire. Available medical equipment is still limited to that carried into the field by medical personnel. Time to evacuation to an MTF may vary considerably.

*CASEVAC* is the care rendered once the casualty has been picked up by an aircraft, vehicle, or boat. Additional medical personnel and equipment that has been pre-staged in these assets should be available at this stage of casualty management.

Based on this overview of the principles that underpin military combat (trauma) care, the capabilities and requirements for an IT-based enhancement are outlined below.

## Military Capabilities and Restrictions

### Medical Capabilities

Researchers focusing on developing triage systems for the battlefield noted that military battlefield scenarios have changed dramatically over the past century from casualty intensive trench warfare to covert, small unit operations.[38] The health and safety of each individual soldier is now essential to the success of every mission. As a result, the care of wounded soldiers in the battlefield is becoming an increasingly important part of military

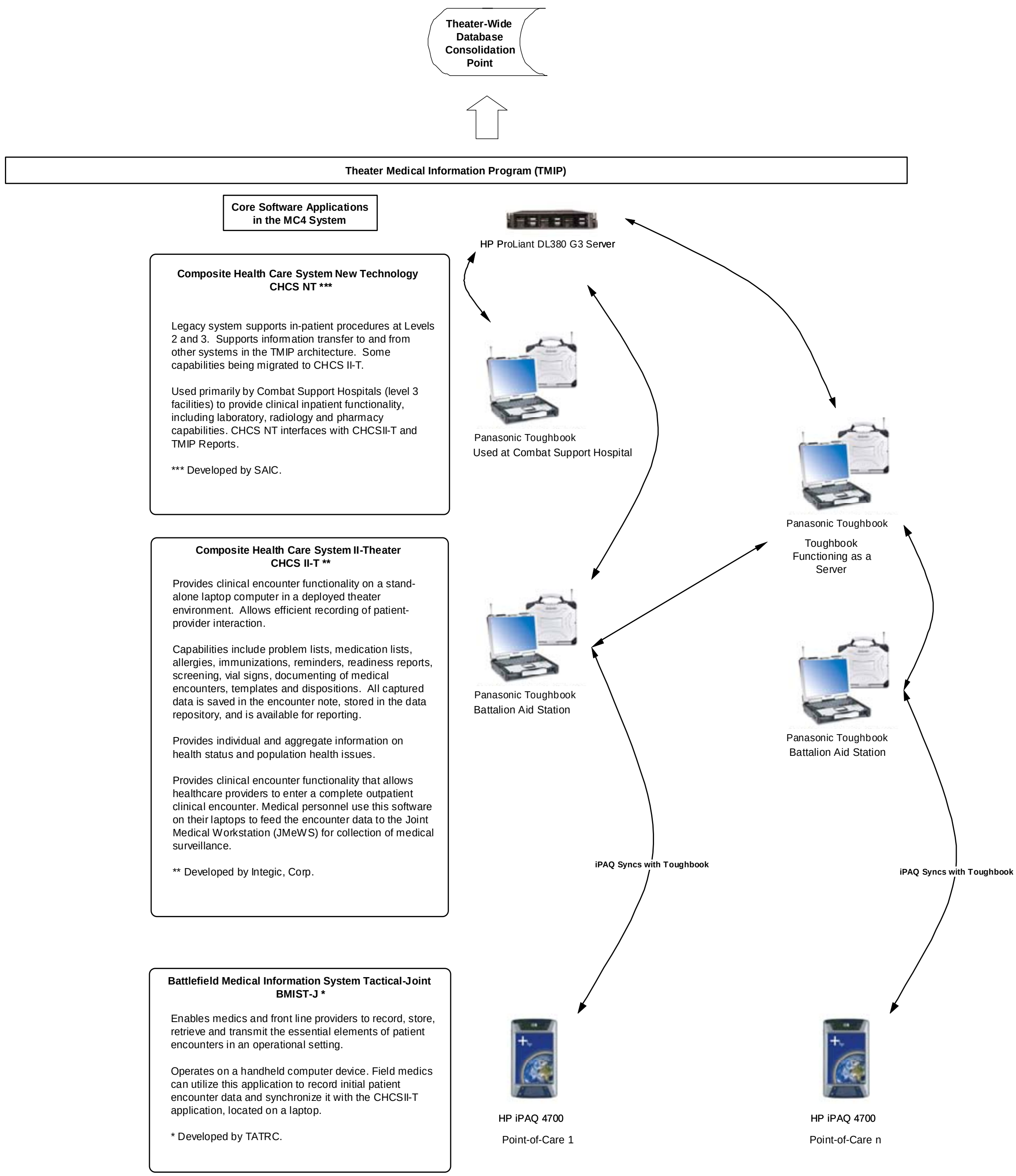
---

[37] Graber MA, Van Scoy D. “How well does decision support software perform in the emergency department?” *Emergency Medicine Journal*, 2003; 20:426-428.
[38] S.M. Wendelken, S.P. McGrath and G. T. Blike, “Agent Based Casualty Care–A Medical Expert System for Modern Triage.” Available online at <http://www.ists.dartmouth.edu/projects/frsensors/artemis/ papers/abccare-suzanne.pdf>.

operations. The extreme conditions of combat make effective casualty care exceedingly difficult and put medics at great risk. Limited communication and resources in the field degrade casualty care and increase risk to the medic. A flexible and efficient communication system that enables seamless exchange of information regarding a soldier's history, medical status, and treatment among all levels of combat care is essential.

Combat care has unique requirements that result from the types of injury and the constraints that result from the limited capabilities in the first echelons of combat care. Work is already underway within DOD to develop and test technologies that provide collection, analysis, and archiving of electronic medical records to make them available at the point of care in battle as well as in a non-battle context. Figure 2 depicts hardware and software components used for data consolidation by the Theater Medical Information Program (TMIP)[i]. TMIP was designed to rectify deficiencies identified during the first Gulf War (Operations Desert Shield/Desert Storm) and other operations. These deficiencies included a lack of consistent information capture within and between the Services, a lack of interoperability between systems, and significant deficiencies in communications between the medical entities of the Services.

# Figure 2. Components used for data consolidation by the Theater Medical Information Program (TMIP)



Hardware and software components used for data consolidation are part of the Theater Medical Information Program (TMIP).[39] TMIP was designed to rectify deficiencies identified during Operations *Desert Shield* and *Desert Storm* and other operations. These deficiencies included a lack of consistent information capture within and between the Services, a lack of interoperability between systems, and significant deficiencies in communications between the medical entities of the Services.

TMIP's goal is to provide the best automated solutions to meet functional needs of the deployed environment. Therefore, not all capabilities required in garrison will be taken to the field. TMIP embraces the "do in war as you do in peace" philosophy—the same systems are used in both environments. TMIP's integrated medical information systems ensure precise, interoperable support for rapid mobilization, deployment, and sustainment of all theater medical services anywhere, anytime, and in support of any mission. TMIP is the medical component of both the Global Combat Support System (GCSS) and the Global Command and Control System (GCCS). The relationship of these systems to DOD IT capability and deployment to the battlefield via the Global Information Grid (GIG) is discussed in a later section of this paper.

In the context of casualty care, several capabilities are under development and are even being deployed in support of the TMIP. Many of these offer IT solutions that may be considerably enhanced in a network-centric battlespace. Specific examples include tools being tested by the Army's Telemedicine and Advanced Technology Research Center (TATRC).[40]

- The Battlefield Medical Information System Tactical—Joint (BMIST-J), "a point-of-care diagnostic tool for first responders, captures basic data from a medical encounter."
- The Personal Information Carrier (PIC) could contain a service member's 20-year longitudinal medical record to include images, is worn with the dog tag, is updated after each medical procedure, and can be used with BMIST and the Composite Health Care System II-Theater (CHCS II-T), which provides clinical encounter functionality on a stand-alone laptop computer in a deployed theater environment and so allows efficient recording of patient-provider interaction.
- The SMARTMC3T equipment set was designed for disaster response/homeland security purposes, but the set has been deployed to Afghanistan. It has voice communication and video teleconference capability, internet access, e-mail, store, and forward imagery capabilities.

In addition to work by DOD agencies, the department is funding a variety of other private and government organizations to develop IT-based capabilities that could be utilized in a military medical environment. These range from individual tools to systems. Some of the more advanced technologies include:

---

[39] Office of the Secretary of Defense, Health Affairs, "Theater Medical Information Program." Available online at <http://www.tricare.osd.mil/peo/tmip/default.htm>.
[40] TATRC capabilities can be viewed at <https://mrmc-www.army.mil/adtindex.asp>.

The goal of the Automated Remote Triage and Emergency Management Information System (ARTEMIS) project is to integrate advances in communications and analysis technologies into a remote triage system that can expedite and improve care of the wounded. [41] In this paper we provide the details of the ARTEMIS military prototype, which can be used to monitor soldiers on the battlefield. The overarching premise of the military version of the ARTEMIS system is that the survivability of our soldiers and mission success can be improved by expanding the flow of medical information on the battlefield and throughout the chain of command. While some casualties are unavoidable, we believe that these specific types of injuries can be reduced and outcomes improved with a more effective analysis and distribution of medical information on the battlefield.

Agent Based Casualty Care (ABC Care) combines networking and sensor technology in a system that addresses these communication issues and automates the diagnostic, treatment, and triage tasks performed by medics. [42] ABC Care incorporates individual computing devices (either wearables or PDAs), a mobile agent information management network, a sensor capable of collecting pertinent physiologic data, an assessment and alert system that analyzes sensor data, an ad hoc wireless routing system that transports and distributes data among computers in the network, and a user interface that allows field and command personnel to access a soldier's health status remotely as well as issue treatment protocols.

In addition to these specific examples of systems that will provide a capability in an IT-enabled battlefield to enhance the work of the medic, there are also efforts within the TMIP that focus on the important network-centric concept of synchronization. One of the most important of these overarching capabilities is the dissemination of theater-wide information.

The rapid dissemination of current knowledge is primarily performed by the Joint Theater Trauma Registry (JTTR). The Registry assembles all combat related care records, to provide near-real-time analysis of cases, to improve prevention or care. As of May 2005, over 7,000 records were in the registry. As an example, additional shoulder padding was added to prevent shoulder injuries that were being experienced. Survival from combat injuries has increased to 90 percent in this conflict, which is 10 percent higher than in Operation *Desert Storm* in the early 1990s and the highest for any conflict. This is due to multiple factors, including increased body armor, but the JTTR has no doubt contributed to the improvement. Early in the current Iraq and Afghanistan conflicts, the value of tourniquet use and the difficulty with hypothermia in association with hypovolemic[43]

---

[41] Susan McGrath, et al., "ARTEMIS: A Vision for Remote Triage and Emergency Management Information Integration." Available online at <http://www.ists.dartmouth.edu/projects/frsensors/ artemis/papers/ARTEMIS.pdf >.
[42] Ibid.
[43] Hypovolemic shock is an emergency condition in which severe blood and fluid loss makes the heart unable to pump enough blood to the body. This type of shock can cause many organs to stop working. < http://www.nlm.nih.gov/medlineplus/ency/article/000167.htm>.

shock resuscitation was identified by JTTR as an area for health care providers to concentrate on.[44]

As we improve the network-centric capabilities in the battlespace, further advances can be anticipated, but this will require a planned development of the IT infrastructure. The plans will need to encompass not just access to the IT-grid, but may also require bandwidth allocation, and other factors as identified below. Choices will need to be made and trade-offs implemented, but all will require consideration of how the network-centric capability can best be used with the medical communities.

## IT Infrastructure

A recent CTNSP publication noted that DOD is investing heavily in information systems to support network-centric military capabilities and joint operations.45 With such programs as Global Information Grid Bandwidth Expansion (GIG-BE), Transformational Satellite Communications Systems (TSAT), Joint Tactical Radio System (JTRS), and Net-Centric Enterprise Services (NCES), DOD is creating a global information backbone and striving to get useful bandwidth and information services to the warfighter. After declining in the 1990s, spending on communications and intelligence has grown by 50 percent since 2001.

The authors of the CTNSP paper also identified that the current IT capabilities of DOD comprise several components.[46] Assembled and coordinated by the Defense Information Systems Agency (DISA), the GIG is "the globally interconnected, end-to-end set of information capabilities, associated processes and personnel for collecting, processing, storing, disseminating and managing information on demand to warfighters, policy makers and support personnel." The GIG includes DOD-owned as well as leased communications, computing systems and services, software, data, and network services. Within the GIG, each of the armed services furnishes its own applications, services, and operating networks.

The GIG supports DOD, the intelligence community, and other parts of the national security establishment in peace and war. It provides capabilities to operate locally, regionally, worldwide, in space, with non-DOD users, and with non-U.S. forces and networks. The GIG operates over three IP-based, router-defined networks for unclassified, secret, and top secret data. Security is provided by separation from the global Internet. GIG networks are maintained by DISA and operated by the Joint Task Force for Global Net Operations (JTF-GNO) under the United States Strategic Command (STRATCOM). In order to ensure tight linkage between maintaining and operating the

[44] Col. Paul D. Mongan et al, "On the Front: Army Anesthesiologists in Operation Iraqi Freedom–Perioperative Consultants Making a Difference on the Battlefield," July 2005, *ASA Newsletter*, Vol 69, Number 8. Available online at <http://www.asahq.org/Newsletters/2005/07-05/mongan07_05.html>.

[45] David C. Gompert, Charles L. Barry, and Alf A. Andreassen, "Extending the User's Reach," Defense & Technology Paper 24 (Washington, DC: Center for Technology and National Security Policy, February 2006).

[46] Ibid.

GIG, the Director of DISA is dual-hatted as the Commander, JTF-GNO, and the two organizations are co-located.

Extending the GIG to all users is DOD's networking highest priority. Five key initiatives comprise that effort:

- Global Information Grid—Bandwidth Expansion (GIG-BE),
- Transformational Satellite Communications (TSAT),
- Joint Tactical Radio System (JTRS),
- Net-Centric Enterprise Services (NCES), and
- Information Assurance (GIG-IA).

Taken together, these investments will go far toward putting in place the infrastructure for information integration in support of operating forces.

It is into this framework that the medical capability for the military will need to be integrated. As noted previously, the TMIP is the medical component of both the GCSS and the GCCS and is linked into the GIG through these portals. Linkage does not, however, equate with access or bandwidth. The requirements for establishing the medical infrastructure to support the types of technology outlined in this paper will need to be properly established, documented, and then incorporated into the priorities for the GIG IT-infrastructure.

With regard to the IT infrastructure that would be required to support the types of medical technologies identified in this paper, it is important to note the considerable differences between combat and non-combat zones.

Mait noted that in a sustaining base, the military and commercial sectors share a common, often static, infrastructure of landlines, fiber optics, and wireless communications.[47] Further, many military and commercial applications are similar, for example, business enterprise applications, such as human resources. In such instances, even though security requirements may differ, the military can rely upon the commercial sector to offer solutions.

However, where commercial and military sectors differ most is in combat tactical operations, where the mobile infrastructure and applications together have no commercial equivalent. Although fire and rescue operations are similar in some respects to tactical military operations, domestic fire and rescue operations can rely upon a sustaining base infrastructure for communications. A tactical military operation must carry its network capabilities with it. Also, although logistics shares some requirements with its commercial equivalents, its requirement to supply warfighters implies adaptation of commercial practices and applications as opposed to simple adoption.

---

[47] Joseph Mait, editor, *Making IT Happen*, Defense & Technology Paper 20 (Washington, DC: Center for Technology and National Security Policy, September 2005).

These differences must be borne in mind when medical IT solutions are deployed into the military environment. A capability that works in a non-combat zone may be less effective or even fail when deployed into a combat zone where the IT infrastructure may be much less robust. The move to a fully enabled network-centric environment may help to address some of these concerns and forms the last part of this case study.

**Network-Centric Operations: Improving IT and Medical Capability in the Battlespace**

The OFT document that explains the basis for NCW/NCO[48] has noted that "net-centric warfare generates survivability."[49] The document further identifies that "NCW generates increasing lethality, survivability, and responsiveness." A major contributor to increased survivability is the development of situational awareness and understanding that results from effective implementation of NCW/NCO.

The basic tenets of NCW, set forth in *Network Centric Warfare: Department of Defense Report to Congress* (July 27, 2001), are as follows:

- A robustly networked force improves information sharing.
- Information sharing enhances the quality of information and shared situational awareness.
- Shared situational awareness enables collaboration and self-synchronization and enhances sustainability and speed of command.
- These, in turn, dramatically increase mission effectiveness.

The capacity to develop increased situational awareness and enhanced situational understanding is an inherent focus for NCW/NCO and is greatly facilitated by immediate accessibility to highly capable low cost IT.[50] The development of situational awareness and understanding in health and disease was the subject of a publication by Armstrong et al.[51] These researchers also developed an analytical approach for assessing which technologies are most appropriate for the task and how they might be developed into a system-of -systems.

In a recent description of NCO Mait et. al noted that: "Vital to the transformation of U.S. military forces is the ability to conduct network centric warfare as defined in DOD

[48] NCO/NCW – The use of network-centric operations (NCO) as the term of reference for the work of the OFT has become more widespread than the original term of network-centric warfare. The two concepts exhibit considerable overlap in terms of analysis, resources, et cetera. Both terms are used in this document, but where specific reference to published work is made, the convention of using whichever term was utilized by the original author has been adopted.
[49] Office of Force Transformation, "The Implementation of Network-Centric Warfare." Accessed August 11, 2006 at <http://www.oft.osd.mil/>.
[50] Arthur K. Cebrowski, "Security Planning and Transformation," March 16, 2004. Available online at <http://www.oft.osd.mil/library/library.cfm?libcol=2>.
[51] Robert Armstrong, Patricia Coomber, Stephen Prior, and Ashley Dincher. *Looking For Trouble: A Policymaker's Guide to Biosensing*, Defense & Technology Paper 1 (Washington, DC: Center For Technology and National Security Policy, June 2004).

Directive 8320.22 dated December 2, 2004 as ‘an information superiority- enabled concept of operations that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization.’”[52] This document also “directs the use of resources by the military departments to implement data sharing among information capabilities, services, processes, and personnel interconnected within the GIG,” the defense-wide network architecture that enables data sharing for achieving network-centric warfare and operations. Other important policy directives and instructions, such as DOD Directive 4630.53 and 4630.84, establish policies and procedures, respectively, for the interoperability and supportability for all aspects of IT and national security systems.

Clearly we are now witnessing the “transformation” that is the *raison d’etre* for the OFT. The development of an effective IT backbone in DOD will enable NCW/NCO integration and facilitate the leveraging of legacy, platform-centric capabilities. According to the OFT, U.S. forces must leverage IT and innovative network-centric concepts of operations to develop increasingly capable joint forces.[53] New information and communications technologies hold promise for networking highly distributed joint and multinational forces and for ensuring that these forces have better situational awareness—about friendly forces and those of adversaries—than in the past.

Notwithstanding the progress noted above there are still barriers to a fully transformed network-centric military. Cebrowski identified four key areas where barriers exist:[54]

- Process barriers
    - Transformation of the management of defense
- Physical barriers
    - Speed of mass (lift and mobility)
    - Speed of information (connectivity and interoperability)
- Fiscal barriers
    - Willingness and ability to devalue and devolve
    - Discretionary versus non-discretionary
- Cultural barriers
    - Speed of understanding versus speed of doctrine
    - Cognitive interoperability and exploitation of shared awareness
    - Values, attitudes, and beliefs.

These represent areas for future analysis of the implementation of NCW/NCO.

[52] Joseph N. Mait, Richard Chait, Albert A. Sciarretta, “Network Centric Operations,” in Defense & Technology Paper 20, *Making IT Happen*, Joseph Mait, ed. (Washington, DC: Center For Technology and National Security Policy, September 2005).
[53] Ibid.
[54] Arthur K. Cebrowski, “Security Planning and Transformation,” March 16, 2004. Available online at <http://www.oft.osd.mil/library/library.cfm?libcol=2>.

Equally there needs to be a consideration about implementation that should be addressed as the NCO/NCW concepts begin to develop within DOD. Hollman identified three fundamental questions:[55]

- What is the relationship between NCO and tactical, operational, and strategic level effectiveness?
- How can we measure progress toward achieving a network-centric force?
- How can we measure the impact of NCO on effectiveness?

This paper describes a civilian example of the use of IT in a network-centric approach that addresses one of the key reasons for implementing NCW/NCO—increased survivability. The example of the civilian healthcare sector provides a useful examination of the challenges for implementing IT, gaining situational awareness and understanding, synchronizing resources, and addressing connectivity and bandwidth issues in complex terrain. These mirror some of the potential issues for the NCO approach in the military medical community. The civilian example, when applied to the current and planned future capabilities for the military also identifies areas where successful implementation may be achieved including novel approaches to issues of limitations on connectivity and bandwidth.

The civilian health sector also can generate data on the related problem of acquiring and maintaining an information network. A 2004 report provided insight into some of the institutional challenges to implementing a transforming NCW/NCO capability in the military.[56] The report used as an analogy the health sector citing the fact that ”There are also sectors, such as health services, with persistent information network problems like those faced by the military, for some of the same conditions of fragmented governance, parochialism, and administrative encumbrance that plague DOD. Information users—namely doctors and patients—have been weak “market players.” Hospital bureaucracies, departmental stovepipes, and IT vendors have had little incentive to provide networks designed for user access and collaboration. Yet this is beginning to change.” The lessons learned from the health sector analysis provide a good starting point for consideration of the challenges for the U.S. military as transformation is implemented.

The implementation of network-centric capability into military medical operations and the increased survivability that can be attained through IT-based enhancement of platform centric resources offers a new area for research into force transformation. Based on the successes in the civilian sector this area of analysis also offers a basis for the examination of some of the key questions that still surround NCO/NCW. Exploration of the issues, implementation of the capability, measuring success through readily defined metrics, and current data collection capabilities, all provide good reasons to continue the

---

[55] K.A. Holloman, “Network Centric Operations Conceptual Framework: IT Value in the Netcentric Organization: Integrating Commercial and Military Perspectives,” December 9, 2003. Available online at <http://www.oft.osd.mil/library/library.cfm?libcol=2>.

[56] David C. Gompert, Charles L. Barry, and Alf A. Andreassen, “Extending the User’s Reach: Responsive Networking for Integrated Military Operations,” Defense & Technology Paper 24 (Washington DC: Center for Technology and National Security Policy, February 2005).

examination of integrating medical capability into NCO. More importantly is the possibility that successful implementation will save the lives of service personnel. In a time of war, with an evolving threat from an adaptable enemy, live-saving "transformation" is an invaluable goal for our military and those who support them in their daily endeavors on behalf of us all.

# Instructor Guide to Battlefield Care Case Study

Taking care of the troops during Operation *Iraqi Freedom* (OIF) has been easier than it was during the first Gulf War due, in part, to an application that enables medical personnel to analyze health trends among warfighters, according to Defense Deployment Health Support officials. Dr. William Winkenwerder Jr., Assistant Secretary of Defense for Health Affairs, told a Congressional panel on March 4, 2004, that the Joint Medical Workstation (JMeWS) was one of several technological innovations that provided surveillance of troop health to commanders, who could also use that data to catch unidentified illnesses quickly. “These capabilities enable medical units to electronically capture and disseminate near real-time surveillance information to commanders,” Winkenwerder said. “Information provided includes in-theater medical data, environmental hazard identification and exposure data, and critical logistics data such as blood supply, hospital bed and equipment availability. TMIP [Theater Medical Information Program], through the joint medical workstation, links care in theater with the sustaining base using interoperable data collection tools. This system serves as the medical component of the Global Combat Support System.”

“Based on our current analysis, over 98 percent of those wounded have survived, and one-third returned to duty within 72 hours,” he said. “It is clear that far forward medical care, improved personal protection and operational risk management techniques continue to save lives. For Operation Iraqi Freedom, the rate of non-combat disease or injury is lower than in any previous U.S. conflict.”

Clearly, survivability of troops and successful missions can be improved by increasing the flow of medical information from the battlegrounds up through the chain of command. This case study reviews the need for network-centric IT healthcare solutions using technological approaches in civilian and primarily in military environments. In addition the case study will also highlight the weaknesses that exist before and after implementation of network-centric capabilities. The case study can be taught with the following objectives in mind:

*Objective 1:* Explain the current deficiencies in battlefield medicine that can be improved upon to reduce mortality and severity of injuries.

*Question 1*: Why is there a need to improve battlefield care and what are the known limitations to battlefield medical applications?

Approximately 25 percent of soldiers killed in action die somewhere between five minutes and six hours from the time of injury. Apparently, the soldiers live long enough to be rescued but die before the current medical treatment system can take affect. The first 30 minutes after an injury is a very critical time period. The survival rates experienced from Iraq and Afghanistan are 10 percent higher than in Operation *Desert Storm*, due largely to improved IT solutions in military operations. However, battlefield medical treatment options are limited to: evacuation, IV fluid, dressing application, surgical control, fracture stabilization, and administering available medications. There is

a great need for an integrated system for diagnostic and procedure support to assist medics in combat and in non-combat. Requirements for future capability shall include the ability to extract information from soldiers and to transform raw data into clinically useful information for military healthcare staff.

*Objective 2:* Demonstrate why civilian sector faces much less adversity in the integration of IT based healthcare capabilities.

*Question 2:* Why have the civilian developers of IT-based healthcare capability not had to face as many limitations?

The civilian sector has incurred fewer problems than the military sector due to the fact that wireless connectivity, broadband access, and other IT support structures have become abundant in the population overall. By comparison, in the forward areas of the battlespace, deployed theater communication infrastructure, often called the "tactical communication infrastructure," provides communication between military units operating in Echelons/Levels 1 through 3. Tactical communication infrastructure is rugged and highly mobile. It is generally composed of radio equipment operating over narrow transmission bandwidths. In addition to constrained capacity, tactical communication is subject to degradation from noise, enemy jamming, and line-of-sight (LOS) limits. It should also be noted that voice circuits can support data transmission, given appropriate modem technology. The limited bandwidth and connectivity represents a considerable challenge to military adoption of civilian capabilities. However, some struggles have been experienced by the civilian sector in rural areas that are not IT enriched and may require some of the innovations that the military is developing.

*Objective 3:* A major objective of casualty/trauma care is to increase patient survivability by moving information and resources closer to casualties in the field.

*Question 3:* What improvements in civilian hospital emergency care have been made that can be applied in the field?

- Development of trauma system in States
- Development of instruments and practices to support medical care (mobile care, ECG)
- Advancement that allows patient information to be gathered electronically at the scene and then be transferred to clinical and operational staff. This allows the hospitals to prepare for a patient in addition to reducing the amount of human error by using an electronic patient care reporting system.

*Objective 4*: Define the Traditional Army Medical Wartime Structure (combat health support).

*Question 4:* Differentiate between the Echelons of the Combat Health Support System and what are the assumptions that need to be made.

The System is built to provide a continuous line of care for a soldier injured on the battlefield ranging from simple interventions in theater to more complex care at a facility within CONUS/Europe.

| Echelon | Facility | Type of Care |
|---|---|---|
| I | Battalion Aid Station | Tactical Combat Casualty Care |
| II | Medical Company | Field Troop Medical Clinic |
| III | Combat Support Hospital | Specialty-based “hospital” care |
| IV | Theater Hospital | Rehabilitate and return to duty |
| V | Home Station Hospital | Long-term recovery |

**Assumptions**

About Medical Structure:

- Echelons are structured for interrupted care and treatments
- Health service support is a single, integrated system
- Viable and timely evacuation system
- Viable medical logistics supplies
- Quality of medical equipment, personnel and training
- Fixed facilities at Echelon IV

About Patient Population:

- Troops represent healthy, young population (mostly male)
- High level of medical/dental readiness in troops
- Troops have good preventive medicine support

About Demand for Services:

- Demand for services will be primarily for trauma and surgical care

*Objective 5:* Identify limited resources on the field that contributes to the less than optimal current combat care.

*Question 5:* What technologies are being developed to improve combat care?

The health and safety of the soldiers is essential to the outcome of a mission. Extreme combat conditions make casualty care difficult and put the medics at risk. It is necessary to have a communications system (or systems) in place that allows for uninterrupted flow of information regarding a solder’s history and medical status, and to have all levels of treatment received for battle and non-battle point of care.

DOD Development Research:

- TMIP (Theater Medical Information Program). Medical component of Global Combat Support System (GCSS) and Global Command and Control System (GCCS). Designed to rectify deficiencies identified during the first Gulf War. TMIP’s goal is to provide the best automated solutions to meet the needs of a

deployed environment. The following capabilities are under development to support TMIP:

1. BMIST-J. Captures basic data from encounter;
2. PIC. Holds medical records of 20 years, including images. To be worn with dog tag; information can be added;
3. SMARTMC3T. Designed for disaster response. Contains voice communication, video telecom, internet, email, can store and forward image

- Other funded research to develop IT-based capabilities that may be applied in a medical military environment.
    1. ARTEMIS. Integrates advances in communications and analysis technologies into a remote triage system that can expedite and improve care.
    2. ABC. Combines networking and sensor technology that makes an individual computing device that allows field and command personnel to access soldiers' health status remotely as well as administer treatment protocols.

*Objective 6:* Show that as network-centric capabilities in the battle space grow, the need for further development of the IT infrastructure to support the capabilities increases.

*Question 6:* What investments are being made to improve network infrastructure and how would the requirements differ from civilian to support the military medical technologies?

Sustaining capabilities in the military and commercial sector share a common infrastructure (land lines, fiber optics, and wireless communications). However, they differ in regard to tactical operation. A capability that works in a non-combat zone may be less effective or fail when deployed to a combat zone, where the infrastructure is less robust. DOD has invested heavily in systems such as the Global Information Grid (GIG). The GIG includes communications, computing systems and services, software, data, and network services to support the DOD and other national security establishments in peace and war. The GIG operates over three IP-based, router-defined networks. Extending the GIG to all users is a priority of DOD. There are five key initiatives to accomplish this effort to put in place the appropriate infrastructure to integrate information for supporting operating forces:

- GIG-BE
- TSAT
- JTRS
- NCES
- GIG-IA

*Objective 7:* Identify barriers that exist that will force future analysis to address to transform to a network-centric military.

*Question 7:* What are the barriers that still exist for a transformed, network-centric military?

- Process (management of defense),
- Physical (speed of mass, speed of information),
- Fiscal (ability to devalue and devolve, discretionary vs. non-discretionary), and
- Cultural (speed of understanding vs. doctrine, cognitive inoperability, values, attitudes, and beliefs).

Exploration of the issues, implementation of the capability, measuring success through defined metrics and data collection capability are all sufficient reasons to continue to examine the integration of medical capabilities into network-centric operations. The lessons learned from the health sector provide a good base for the challenges that face the military as transformation is implemented.